The Urban Biodiversity Information Node pilot (UrBIN), part of the National Biological Information Infrastructure (NBII), aims to provide communities with the information and tools needed to proactively manage urban natural resources. As citizens, elected officials, and researchers seek to address the issues and impacts associated with rapid landscape change in our nation's metropolitan areas, it is increasingly clear that the knowledge base for making wise land use decisions is lacking in many respects. UrBIN is being developed as a response to this need. UrBIN's goal is to serve a coordinating role in the delivery of standards, tools, and techniques necessary to find and make use of biological resources information. Stakeholders in UrBIN include resource managers, scientists, educators, and the general public.

Of the myriad natural resource issues faced by cities and metropolitan areas, biodiversity conservation is particularly difficult to address. Researchers have only recently begun to document links between biodiversity and public health, safety, and welfare. As a consequence, the time and resources devoted to investigations of urban ecology and biodiversity is a small fraction of that given to water resources research, for example. This situation is rapidly changing, however, as the academic community, elected officials, and resource planning agencies scramble to respond to the consequences of urban sprawl and unprecedented levels of land consumption.

As communities establish urban natural resources programs, there is concern over the degree to which existing scientific knowledge can support sound decision making. UrBIN seeks to provide a framework that provides access to existing studies and data, but also makes clear where gaps in the knowledge base exist. UrBIN also seeks to develop and refine a coordinated process for communities to follow in assembling the information necessary to make land use and natural resources decisions. The pilot UrBIN study of the Holmes Run/Cameron Run watershed is the first step in establishing this framework and developing applicable decision support tools.

The Holmes Run/Cameron Run watershed is part of the Potomac River basin in the Washington, D.C. metropolitan area. At the point where the stream's mainstem enters the Potomac, it is called Hunting Creek. Major tributaries include Backlick Run, Indian Run, Turkeycock Run, and Tripps Run. Lake Barcroft is the major waterbody in the watershed. The watershed includes portions of Fairfax County, Alexandria, and Falls Church.

Holmes Run/Cameron Run provides an interesting test case for urban biodiversity analyses because the entire watershed is highly urbanized. This pilot study demonstrates one scenario that is common throughout the metropolitan D.C. area. Future studies to further develop the UrBIN framework will likely explore other common scenarios, such as partially built-out watersheds and those just beginning to feel development pressures. Consideration of a range of development conditions is an important part of understanding urban ecology issues and developing the means to apply that understanding. Certainly biodiversity and threats to it vary greatly across an urbanized region, particularly in relation to development density. The Holmes Run/Cameron Run pilot study focuses on one case of that variability – the highly urbanized state.

One component of the Holmes Run/Cameron Run Watershed study, documented in this report, is landscape characterization and spatial analysis. The goal is to understand what urban biodiversity means in this watershed, achieved by examining the study area from several perspectives. The first step in landscape characterization is the landscape inventory and assessment, a review of physical and biological conditions in the watershed as well as demographics and land use. Spatial analyses using geographic information systems (GIS) are explored to identify interesting patterns and trends at the watershed scale. Public policies affecting biodiversity conservation, especially those concerning land use and water resources, are also reviewed. Conclusions are drawn regarding the effects of landscape patterns and policies on biodiversity in the watershed.

Developing an understanding of biodiversity in the Holmes Run/Cameron Run watershed and documenting the process for achieving that understanding are important parts of the UrBIN pilot study. However, this research must be set in the context of a broader process for biodiversity planning to have relevance for future studies. This report includes an overview of environmental planning approaches that might be expanded to address urban biodiversity.

The report is divided into four parts. Part 1 discusses the special circumstance of *urban* biodiversity and contains a description of the watershed, its history, and a summary of Virginia's Chesapeake Bay regulations. These regulations are the impetus for much of the natural resource planning activities in the region. Part 2 contains the landscape inventory of physical and biological resources and analyses of land use and land cover. Part 3 addresses biodiversity planning considerations. Finally, Part 4 contains concluding thoughts on this phase of the UrBIN pilot project.

Section Break (Next Page)

Part 1

Biodiversity in an Urban Watershed

Centuries of human activity have had a dramatic effect in the Holmes Run/Cameron Run watershed. The process of landscape transformation began when Native Americans settled in the floodplains of the Potomac River. From that time to the present, changes, both natural and man-made, have taken place. However, the most radical alterations of the landscape have occurred since 1950. Suburban expansion and the growth of the Washington, D.C. metropolitan area have created what is dense development by U.S. standards.

Such a landscape challenges common conceptions of biodiversity and natural systems. And yet remnant natural systems continue to function in the watershed. Flora and fauna also thrive in a multitude of habitat niches within the watershed. Understanding biodiversity in the Holmes Run/Cameron Run watershed requires an understanding of the physical and biological characteristics of the landscape as well as an understanding of the people who live there and how they manage their land and water resources. In Part 1, this process of understanding begins – first with an overview of the state of science regarding urban biodiversity and then with a description of the study area, its history, and its regulatory context.

1.1 What is Urban Biodiversity?

Biodiversity is simply defined as the variety of life and all processes that keep life functioning (Keystone Center, 1991). It is studied at genetic, species, and ecosystem levels. Global efforts to manage biodiversity aim to arrest species extinction and preserve intact natural ecosystems. Ecosystem management is an approach applied usually to wildlands to protect biodiversity.

"Urban biodiversity" can be viewed as an oxymoron. The term has come into vogue with the realization that urban areas often contain more biological diversity than their surrounding farmland and that remaining natural areas in cities provide not only habitat for many species, but also treasures to a human populous that increasingly values natural surroundings. While the context for urban biodiversity is far different from wildland biodiversity, many of the same principles and approaches apply.

Urban development obviously impacts biodiversity through land disturbance and conversion to impervious surfaces, removal of native vegetation, introduction of non-native exotic species, and fragmentation and isolation of remaining natural areas. Efforts to manage urban biodiversity aim to minimize and mitigate those impacts, protect and connect remaining habitats, and restore damaged natural areas. The purpose of studying the Holmes Run/Cameron Run watershed is to gain a better understanding of the degree of diversity in a highly urbanized setting and to understand the institutional constraints and opportunities for biodiversity conservation and enhancement at the local government level.

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1.1.1 The Emerging Science of Urban Biodiversity

In recent years there has been an explosion of interest in biodiversity and urban ecology. However, the intersection of the two concepts, *urban biodiversity*, is just beginning to attract the attention of researchers and landscape managers. Much of the research to date concerns the impacts of urban development on biodiversity, especially in the urban fringe (Whitford, Ennos, and Handley 2001). A shift toward the characteristics of the urban areas themselves can be seen in the work of Niemela (1999); Savard, Clergeau, and Mennechez (2000); and Godefroid (2001). While a number of authors discuss the value of biodiversity for cities and applicable theories and concepts, few have provided empirical evidence of the structure and function of urban green space. Studies such as Godefroid (2001) are the exception, but they are essential to provide a foundation for biodiversity preservation and restoration activities in cities.

The science of urban biodiversity is emerging in the work of researchers from many disciplines, like those connected with the Urban Long-term Ecological Research (LTER) programs established by NSF in Baltimore and Phoenix. The science of landscape ecology is a major influence on this research as well as on various biodiversity conservation initiatives. The UrBIN pilot can benefit from this growing body of research.

1.1.2 Urban Long-Term Ecological Research Program

In 1997, NSF's Long-term Ecological Research (LTER) program funded two urban study areas in Baltimore and Phoenix to advance the state of scientific understanding of urban ecosystems. The program studies and monitors human impacts on land use and land-cover change in urban systems, relating these effects to the overall ecosystem; develops tools for collection and analysis of socioeconomic and ecosystem data; and develops integrated approaches linking human and natural systems in urban environments.

The Baltimore LTER (http://www.ecostudies.org/bes/) organizes its research around three hierarchies or patch units: land cover-ecological hierarchy, watershed hydro-ecological hierarchy, and socio-economic hierarchy. The program focuses on three fundamental questions:

- What are the fluxes of energy and matter in urban ecosystems, and how do they change over the long term?
- How does the spatial structure of ecological, physical, and socio-economic factors in the metropolis affect ecosystem function?
- How can urban residents develop and use an understanding of the metropolis as an ecological system to improve the quality of their environment and their daily lives?

The Central Arizona-Phoenix (CAP) LTER (http://caplter.asu.edu) is studying the structure and function of the urban ecosystem, assessing the effects of urban development on the Sonoran Desert, and defining the impact of ecological conditions on urban development. The program cites three research "nuggets" from its first few years:

- anthropocentric sources of nitrogen far outstrip natural sources in the nitrogen balance of the CAP ecosystem;
- the "wave of advance" of urban residential development at the periphery of the Phoenix metropolitan area determines changes in microclimate, soils, and vegetation; and
- ethnic minorities are exposed to greater environmental hazards than other population groups.

Addressing the broader issues of urban ecology and the intersection of natural and social systems, such basic and applied research promises a level of understanding of urban ecological systems not previously attained. Some of these initial findings support those reported by Godefroid (2001) in a study of urban plant diversity. Examining plant composition in Brussels over a 60-year time period, Godefroid found that species distribution and abundance were affected by human activities, with the decline or disappearance of some species, but also with the appearance of new species, many of which were aliens. Godefroid found that alien species were favored in cities because of their increased tolerance of nitrogen, light, drought, heat, and alkaline soils. More research of this kind is needed to support urban biodiversity impacts and protection efforts.

1.1.3 Landscape Ecology

Biodiversity conservation, especially in an urban context, is guided by the principles of landscape ecology that determine habitat quantity and quality and therefore species abundance and variety. Landscape ecologists organize spatial structure with four basic components: matrix, patch, corridor, and mosaic:
- **Matrix** is the land cover that is dominant and interconnected over majority of land surface (e.g., forest, agriculture, urban).
- **Patch** is a nonlinear polygon area less abundant than and different from the matrix.
- **Corridor** is a linear or elongated patch that links other patches in the matrix.
- **Mosaic** is a collection of patches none of which are dominant enough to be interconnected throughout landscape.

In general, the biodiversity potential of the urban matrix can be enhanced by increasing the number, size, and variety of patches of natural vegetation and integrating these patches through a variety of natural corridors, such as riparian and stream corridors.

Urban wildlife specialists have long assumed that the provision of habitat core patches and connecting corridors would provide the needed infrastructure for urban biodiversity. Recent research, however, suggests that while these simple elements are necessary, they may not be sufficient for effective conservation. For example, Scott and Allen (2001) describe several factors that can impede movement and what they call "functional connectivity" even when corridors exist: corridors are too narrow, too long, too heterogeneous to provide unbroken pathways, or too reliant on introduced rather than remnant corridors; corridors and patches are designed in isolation and not as a coordinated system; and ecosystem dynamics are so altered by habitat fragmentation that simple patches and corridors are not sufficient to restore them.

1.2 Watershed Description

Within northern Virginia's I-495 beltway lies a stream whose reaches are alternately identified as Holmes Run, Cameron Run, and Hunting Creek. The longest stretches of the creek are called Holmes Run (mostly in Fairfax County) and Cameron Run (in the City of Alexandria), with the name Hunting Creek used for the section near the confluence with the Potomac River. For the purposes of this report, the watershed is identified as Holmes Run/Cameron Run.

The Holmes Run/Cameron Run watershed lies in the Middle Potomac-Anacostia-Occaquan basin (Figure 1). It is a multi-jurisdictional watershed with 31.5 square miles of its total estimated area (42 square miles) lying in the eastern portion of Fairfax County. The remaining area lies in the cities of Alexandria and Fall Church (Figure 2). The principal tributaries of Holmes Run/Cameron Run are Tripps Run, Backlick Run, Turkeycock Run, Indian Run, and Pike Branch. Lake Barcroft (137 acres), Fairview Lake (15 acres) and four regional ponds are also apart of the watershed (Figure 3).
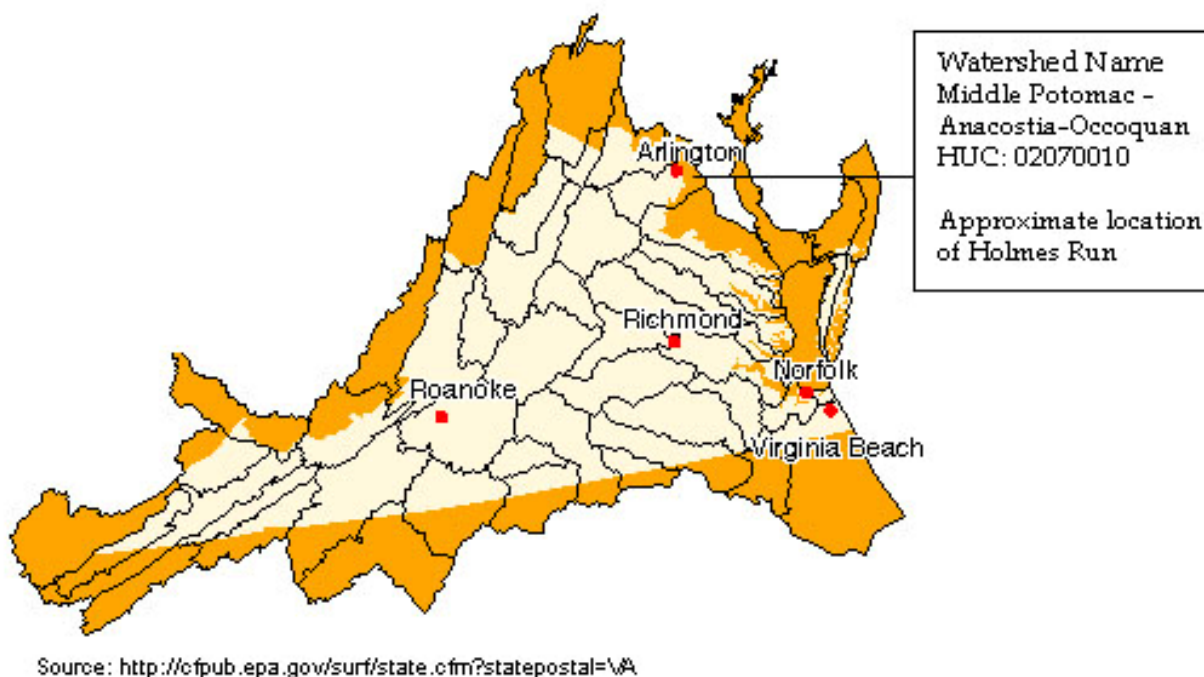

Source: http://cfpub.epa.gov/surf/state.cfm?statepostal=VA

Figure 1. The Middle Potomac-Anacostia-Occoquan Basin

The headwaters of Holmes Run lie near the junction of the Capital Beltway (I-495) and I-66, approximately 1.5 miles west of the City of Falls Church (Figure 4). Flowing south and east, Holmes Run drains a portion of the area between Tysons Corner and the cities of Vienna and Falls Church. The stream crosses beneath four major highways before flowing into Lake Barcroft. The other stream flowing into Lake Barcroft is Tripps Run. It drains the southwestern half of the City of Falls Church. The Lake Barcroft dam is positioned at the confluence of Holmes Run and Tripps Run. Approximately 4 miles southeast of the dam, Holmes Run meets Backlick Run, and the name of the mainstem changes to Cameron Run.

In Alexandria, Cameron Run drains the southern and western portions of the city except areas of Old Town that drain directly to the Potomac River. Cameron Run is a flood control channel whose

surrounding area is characterized primarily by business and residential development. Pikes Branch and Hunting Creek Branch are the named tributaries that flow into Cameron Run. Most of the tributaries in the Alexandria area are either channelized or in pipes. At the point where Hunting Creek Branch joins Cameron Run, the name of the mainstem changes to Hunting Creek.
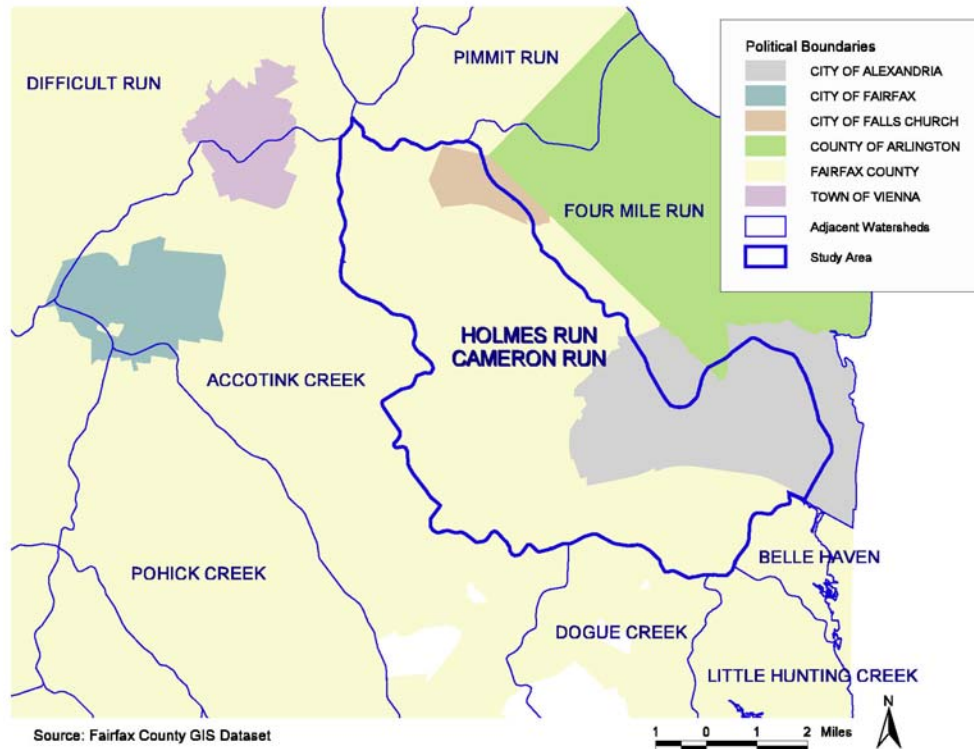

Figure 2. Political and watershed boundaries

Backlick Run and its two major tributaries, Turkeycock and Indian Runs, drain the southwest portion of the Holmes Run/Cameron Run watershed. Encompassing approximately one-third of the watershed, Backlick Run is a substantial contributor to Cameron Run. Its headwaters originate in Annandale, closely paralleling the Capital Beltway (I-495) for most of its length. Indian Run and Turkeycock Run drain the high-density residential area around Annandale. East of its confluence with these tributaries, Backlick Run enters the City of Alexandria and meets Holmes Run (Fairfax County Stream Protection Strategy Baseline Study, 2001).

1.3 Historical Overview

Today, the Holmes Run/Cameron Run watershed resembles the kind of medium- to high-density urban development found in major metropolitan regions throughout the U.S. Understanding floral and faunal distributions in this highly altered environment requires an understanding of the historical land use changes that have taken place here. A historical overview of the watershed is provided by the Cameron Run Environmental Baseline study (Parsons Brinckerhoff, 1974), summarized below.

Prior to European settlement, the Holmes Run/Cameron Run watershed was predominately forested, with three major plant associations following the demarcations of the physiographic provinces. In the northwestern section of the watershed, part of the Piedmont, the forest was composed of oaks and hickories, a subregion of the Piedmont oak-chestnut forests. In the southeastern section of the watershed, part of the Coastal Plain, the forest was composed of oaks and pines. American beech forests occupied the space in between, the Fall Line.

Native Americans began the process of altering Holmes Run/Cameron Run. They cleared forests and planted crops along the Potomac River. They probably also farmed the lower valleys of its tributaries. Native Americans hunted game animals in the inland regions of the watershed, trapped fish, and collected huge numbers of fresh water mussels.

When European settlers arrived in the area, they purchased meat, hides, and crops from the Native Americans. More extensive habitat alteration soon became evident as some animals disappeared and more forest was converted to agriculture. The first land patents were made along the Potomac River in 1653, followed by settlements in 1690. The first settlement of the City of Falls Church was in 1699, and the city became a township in 1875. The first settlement in Fairfax County was in the early 1600s, followed by its formal creation in 1742. Incorporated in 1779, the City of Alexandria received city status in 1852.
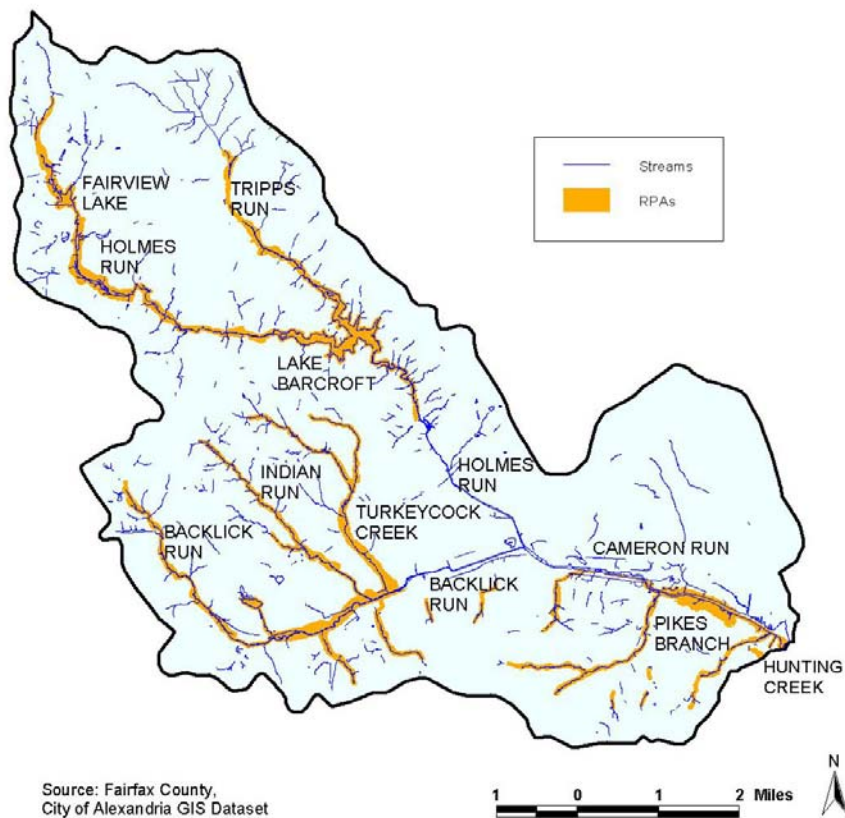

Figure 3. Streams, waterbodies, and Resource Protection Areas

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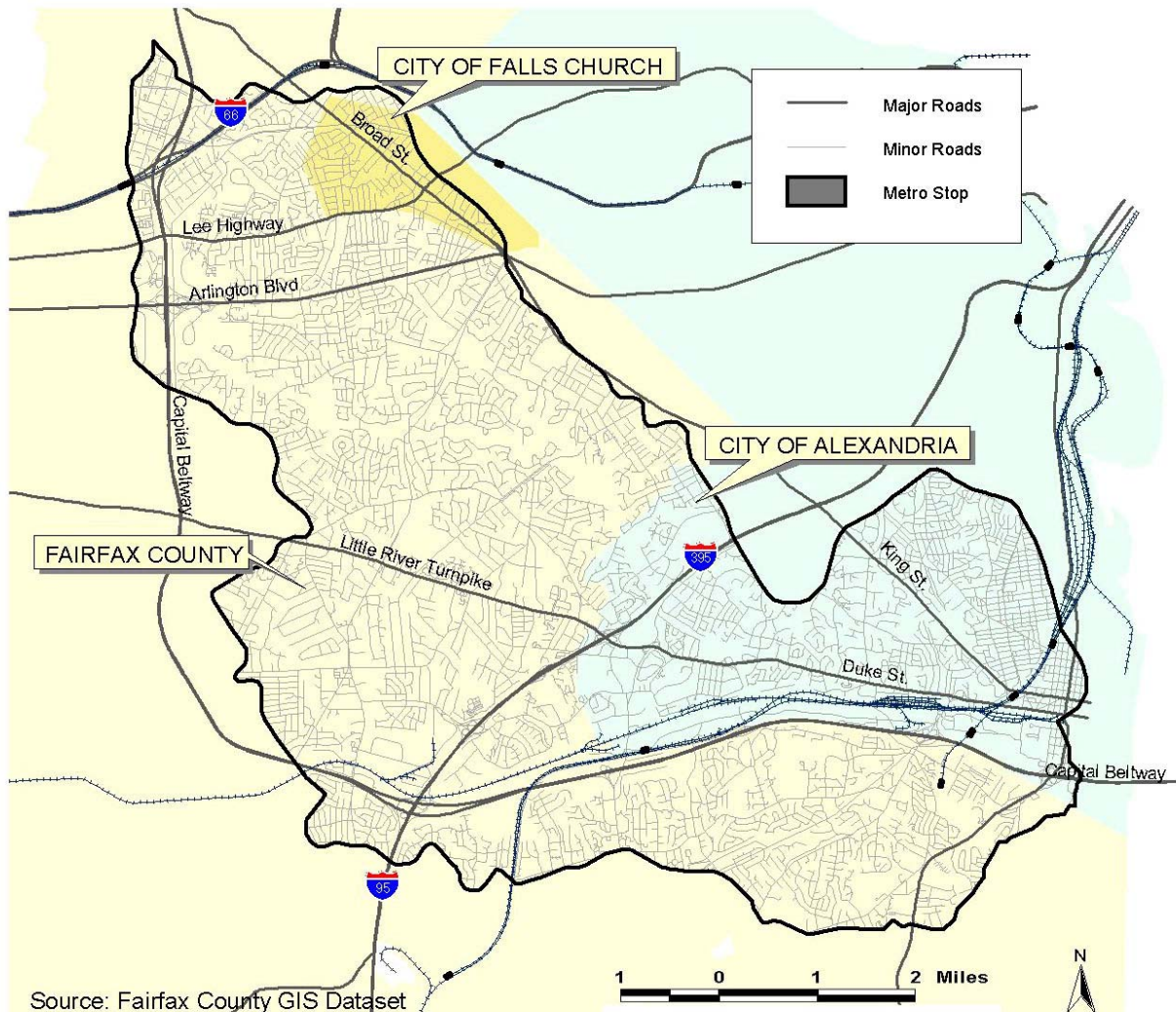

Figure 4. Major transportation routes

Farms were built in the hinterland of the watershed around 1723. The cultivation of crops, particularly tobacco, wheat, and corn took place during the 18th century. A major tobacco warehouse was built in 1732 on the north bank of Hunting Creek, and many of the first roads in the watershed were "rolling roads" for tobacco. With the lack of knowledge about conservation practices, soil was exhausted by 1800. Despite the introduction of fertilizers, abandoned fields were numerous and large tracts of Fairfax County appeared to be desolate.

In 1850, the first of several railroad tracks in the watershed was built. It ran along the valley of Hunting Creek, to Cameron Run and Backlick Run, extending from Alexandria and across to

Accotink. An 1879 map of Fairfax County showed 425 buildings in the watershed, including four water-powered grain mills and one sawmill.

The turn of the 20th Century brought the expansion of the federal government and post-Civil War industrialization to Washington, D.C. The watershed saw its first subdivisions by 1920. The first sewer lines ran from Falls Church to the Potomac, along Tripps Run, Holmes Run, and Cameron Run. In the 1950s, major sewers were installed along Backlick Run, Turkeycock Run, and Indian Run. Residential subdivisions covered a substantial portion of the watershed (the area north of I-95) by the end of the decade. This caused overland erosion that washed huge amounts of silt into the streams during severe storms.

Sedimentation was not the only problem for area streams. The trunk lines running along the Holmes Run/Cameron Run mainstem dumped raw sewage into the Potomac until 1954. Alexandria's raw sewage drained into Hunting Creek and the Potomac until 1956. Today, two Virginia Department of Environmental Quality(DEQ)-permitted combined sewer outfalls from the City of Alexandria discharge into Hoofs Run, a tributary of Cameron Run.

By the 1970s, growth around the watershed was directly attributable to federal employment expansion, in addition to the service industries that assisted this expansion. Private economic interests contributed to unprecedented commercial growth in Fairfax County and the City of Alexandria in the 1980s. In contrast, the 1970s and 1980s were marked by slow growth in the City of Falls Church due to the limited amount of available land. Today, all three jurisdictions are virtually built-out, making redevelopment and infill projects the priority for the next two decades.

For additional information on the history of this part of Northern Virginia, see www.fairfaxcountyeda.org/history.htm, www.falls-church.lib.va.us/history/gfc2.htm, and www.ci.alexandria.va.us/city/about-alexandria/about.html#history.

1.4 Chesapeake Bay Regulations

The potential for biodiversity conservation in the Holmes Run/Cameron Run watershed is closely tied to Chesapeake Bay issues and regulations, since the study area is located in the bay watershed. With over 3,600 species of plants, fish and animals, the Chesapeake Bay is among the nation's largest, most productive, and diverse estuaries. However, various land uses and human activities have generated sediments, pesticides, fertilizers, motor oil, and other pollutants in the 64,000 square mile watershed (Figure 5). Impacts from these pollutants continue to increase as the population surrounding the watershed grows (City of Alexandria Water Quality Management Supplement, 2001). The reduction in water quality threatens both aquatic and human health. In addition, economic interest and recreational benefits are lost as aquatic and waterfowl species become threatened and endangered.

In 1983, Virginia, Pennsylvania, Maryland, the District of Columbia, the U.S. Environmental Protection Agency and the Chesapeake Bay Commission signed the Chesapeake Bay Agreement that established a program to restore the bay. The goal of the program in Virginia is to "protect the public interest in the Chesapeake Bay, its tributaries, and other state waters and the promotion of the general welfare of the people of the Commonwealth" (www.cblad.state.va.us/bayact.htm). In

2000, the same partners signed a new agreement to reaffirm their commitment to the protection and restoration of ecological integrity, productivity, and beneficial uses of the Chesapeake Bay system (Chesapeake 2000 Agreement).
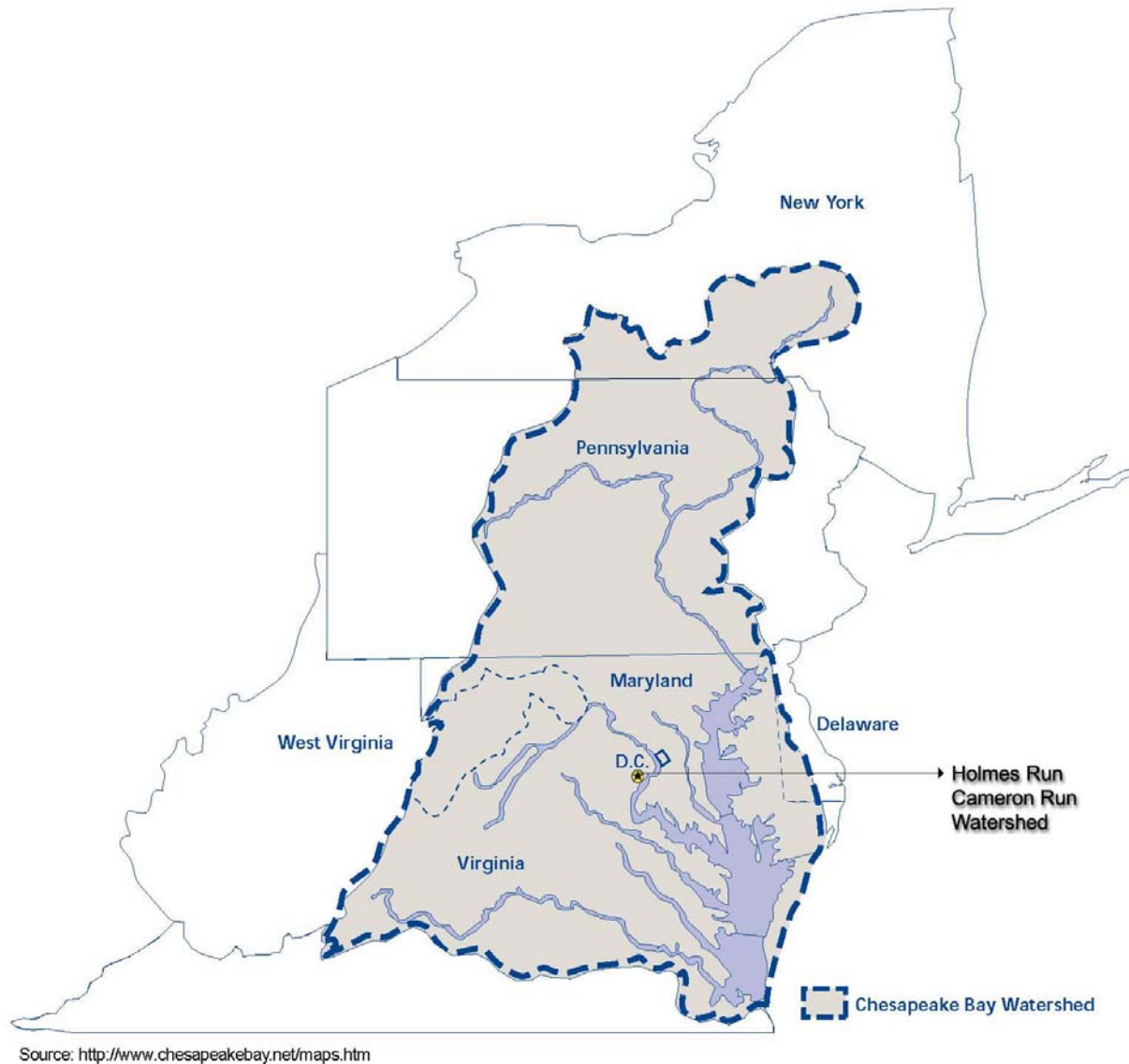

Source: http://www.chesapeakebay.net/maps.htm

Figure 5. Chesapeake Bay Watershed

The Virginia Chesapeake Bay Preservation Act (Chapter 25, Title 10.1 of the Code of Virginia) was created to curb the ecological degradation of the bay by urban and agricultural nonpoint source pollution. It recognizes that local streams and watersheds are also suffering the effects of pollution and are no longer capable of supporting aquatic life. The Act requires counties, cities and towns of Tidewater Virginia, among other responsibilities, to incorporate measures of water quality protection into their comprehensive plans, zoning ordinances, and subdivision ordinances (www.cblad.state.va.us/bayact.htm). The Act also requires "the establishment of programs that define and protect certain lands called Chesapeake Bay Preservation Areas, which if improperly

developed may result in substantial damage to water quality of the Chesapeake Bay and its tributaries" (www.cblad.state.va.us/bayact.htm). As part of the Act, the Chesapeake Bay Local Assistance Board (CBLAD) was formed to establish criteria that provide water quality protection and accommodate economic development in Tidewater Virginia. Fairfax County and the Cities of Alexandria and Falls Church are among those jurisdictions that comprise Tidewater Virginia.

The Chesapeake Bay Preservation Area Designation and Management Regulations require the designation and mapping of Resource Protection Areas (RPAs) (see Figure 3) and Resource Management Areas (RMAs). An RPA is "that component of the Chesapeake Bay Preservation Area comprised of lands at or near the shoreline that have an intrinsic water quality value due to the ecological and biological processes they perform or are sensitive to impacts which may result in significant degradation to the quality of state waters" (www.cblad.state.va.us/glossary.htm#R). In its natural condition, this land provides the removal, reduction or assimilation of nonpoint source pollution entering the bay and its tributaries. The following lands are classified as RPAs: tidal wetlands, non-tidal wetlands connected by surface flow to tidal wetlands or tributary streams, tidal shores, tributary streambeds (not owned by the Commonwealth of Virginia), and buffer areas 100 feet in width for the previously mentioned categories. RMAs include land that has a potential for causing degradation to water quality or to an RPA if it is not used properly. While RPAs are defined by the regulation, RMAs are determined by local discretion. The regulations also permit local jurisdictions to designated "other lands" as either RPAs or RMAs if they are considered environmentally sensitive.

The Chesapeake Bay regulations are an important part of natural resources planning in the Holmes Run/Cameron Run watershed. They will be considered again in Part 3 as a component of the land use policies affecting biodiversity. First, Part 2 presents a landscape assessment of the watershed.